RESEARCH BRIEF

Growing Toward a Low-Carbon Future

Policy Implications of Greenhouse Gas Emissions and Their Trade-Offs in California's Westlands Water District

On September 16, 2022, California Governor Gavin Newsom signed into law a sweeping set of bills intended to curb the state's greenhouse gas (GHG) emissions, including through croplands and other working lands.[1] This is one of many ways California is asking how agriculture contributes to climate change, how the sector can decarbonize and contribute to the state's emissions reductions goals, and what policies the state should advance. In addressing agricultural GHG emissions, Californians must also balance food security, employment and economic impacts, water resources, biodiversity, and a host of other agriculture-related concerns.

Although these questions can be asked at a state level, they must ultimately be answered locally, by agricultural districts; irrigation districts; and individual farmers who make near-term, bottom-line choices about what to grow, what agricultural practices to use, what investments to make in renewables, and how to support those choices financially. Whether crop producers are net emitters or net sequesterers of carbon depends on each farm and region's unique geography, water resources, climate, and agricultural practices.

The authors examined these trade-offs and the GHG emissions of crop production in Westlands Water District. They developed a bottom-up carbon and nitrogen cycle model to estimate parcel-level emissions from 37 different crop types

KEY FINDINGS

- Crop production and land use in Westlands releases about 1.2 metric tons of carbon dioxide equivalent (MtCO2eq) per acre per year, on average, from 2020 to 2050.
- Almonds, pistachios, and fallowed land are the major contributors to these emissions because of the number of acres planted.
- When offsets from solar generation are considered, emissions drop to an average of 0.47 MtCO2eq per acre per year from 2020 to 2050.
- In the short term, Westlands offsets more emissions than it releases through solar generation and does not start contributing net emissions until 2033.
- Introducing no-tillage practices would reduce net emissions to 0.12 MtCO2eq per acre per year.
- Converting a portion of land to solar generation in 2025 shifts the year in which Westlands becomes a net positive emitter out to 2043.
- More-widespread planting of crops that sequester carbon, such as processing tomatoes, corn, and hay, could offset emissions further.

and five different land uses (e.g., solar energy generation, pasture). This model was coupled with a water use model and an energy use model. Together, this modeling framework allowed the authors to examine crop- and regional-level emissions from existing practices in Westlands and how alternative practices, such as the expansion of solar energy generation in the district, could result in water trade-offs and could affect cultivated acreage.

Although similar models have been used in national or international contexts, a bottom-up analysis of the GHG emissions of agriculture has not yet been done in California. In this policy space, the authors addressed the following research questions for Westlands:

- What existing crop production and related land use practices account for the most and least GHG emissions?
- How do GHG emissions from crop production and related land uses change under climate change?
- How would changes in crop production and related land use practices affect GHG emissions and key resource trade-offs, such as water use?

Westlands Is Offsetting Agricultural Emissions with Solar Energy Generation

The authors found that crop production and land use in Westlands will release about 1.2 metric tons of carbon dioxide equivalent (MtCO2eq) per acre per year, on average, from 2020 to 2050.[2] Almonds, pistachios, and fallowed land are the major contributors to these emissions in Westlands, which is due to the number of acres planted. However, when emissions offsets from solar generation from the over 15,500 acres dedicated to solar in the district are factored in, this value drops to an average of 0.47 MtCO2eq per acre per year from 2020 to 2050 (Figure 1). Although these are average values across the study horizon, annual emissions change over time. In the short term, Westlands offsets more emissions than it releases through solar generation and does not start contributing net emissions until 2033. This transition happens as California's grid becomes less carbon intensive over time,[3] and the net offset from solar declines.

The authors also examined average annual per-acre emissions by crop groups,[4] as well as the four sources of emissions for each of these categories. Figure 2 shows that maize and grain sequester the most carbon per acre. Figure 2 also illustrates that cotton has the highest per-acre emissions, mostly because of the use of on-farm equipment. Fruits and vegetables also have high per-acre emissions because of on-farm equipment. Tree crops, such as almonds and pistachios, have high per-acre emissions. For almost all crop groups, emissions from pumping for irrigation are a small proportion of overall emissions.

Westlands Could Decarbonize Further with a Portfolio of Actions

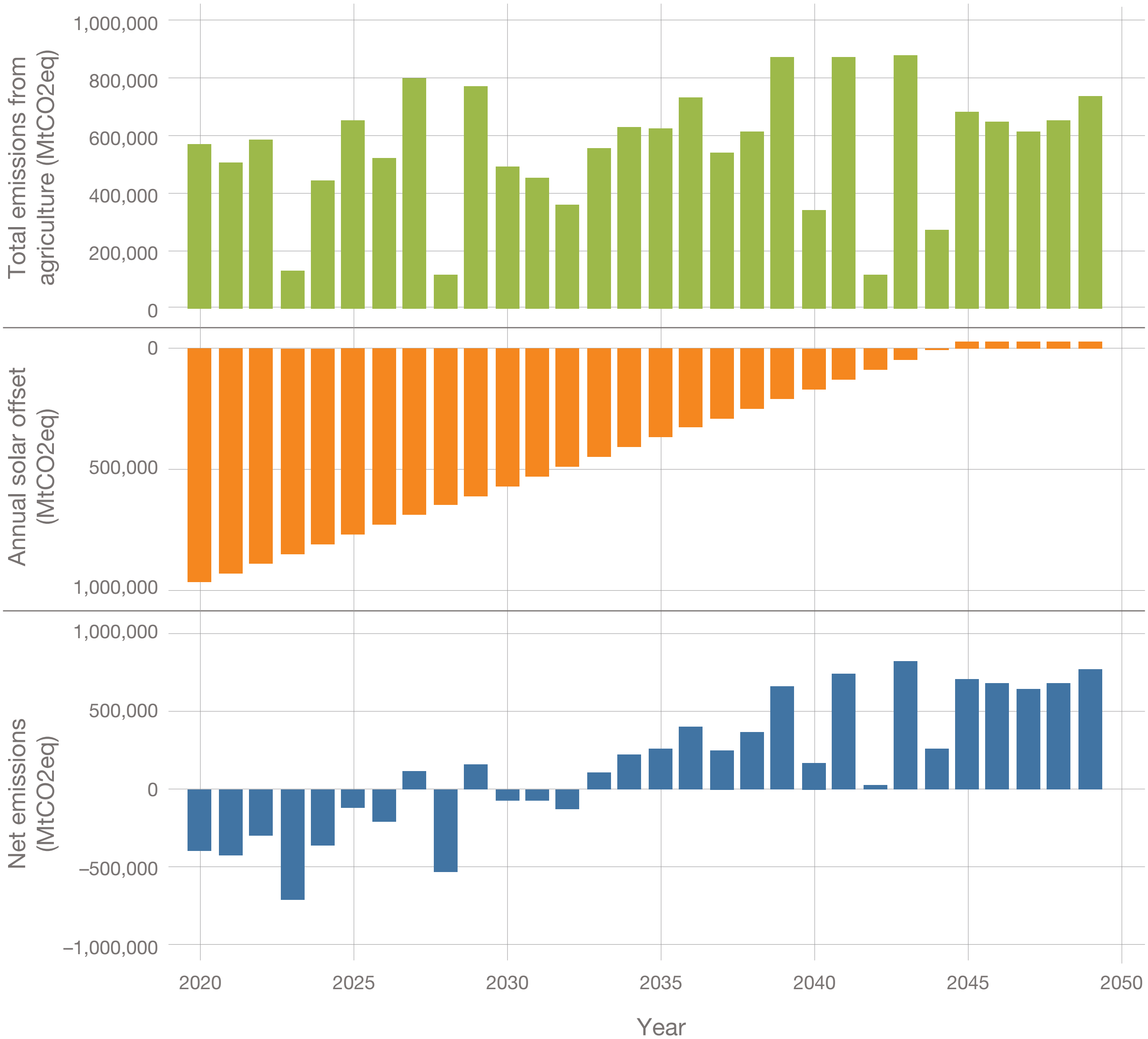
The findings of this study show that Westlands is currently a net negative emitter and suggest that a portfolio approach to further emissions reductions could maintain this status to 2043 and reduce any net positive emissions in subsequent years. Although this study did not consider the cost of the various alternative practices, the total emissions reductions are greatest if Westlands considers (1) converting a portion of Westlands-owned lands to solar by 2025, (2) recommending the use of no-till practices across all farms within the district, and (3) switching all groundwater pumps to California's renewable portfolio standard.

Specifically, the authors found that introducing no-tillage practices across all farms in the district[5] would reduce net emissions from 0.47 MtCO2eq per acre per year to 0.12 MtCO2eq per acre per year, a net emissions reduction of over 75 percent. Furthermore, expanding solar in the district by converting a portion of Westlands-owned land[6] to solar generation in 2025 provides the largest reductions in emissions and shifts the year in which Westlands becomes a net positive emitter to 2043. Finally, when this alternative of additional land conversion to solar is combined with no-tillage practices, any positive emissions after 2043 are reduced without increasing water demands.

The authors also found marginal emissions reductions from the ubiquitous use of organic fertilizer across the district. Although these values are small, they do accrue over time, and policies to promote the use of organic fertilizer could offer other co-benefits not considered in this work.

Finally, Westlands could consider promoting a crop mix that offers greater sequestration. Such crops as processing tomatoes, corn, and hay sequester more

FIGURE 1
Westlands Net Emissions to 2050



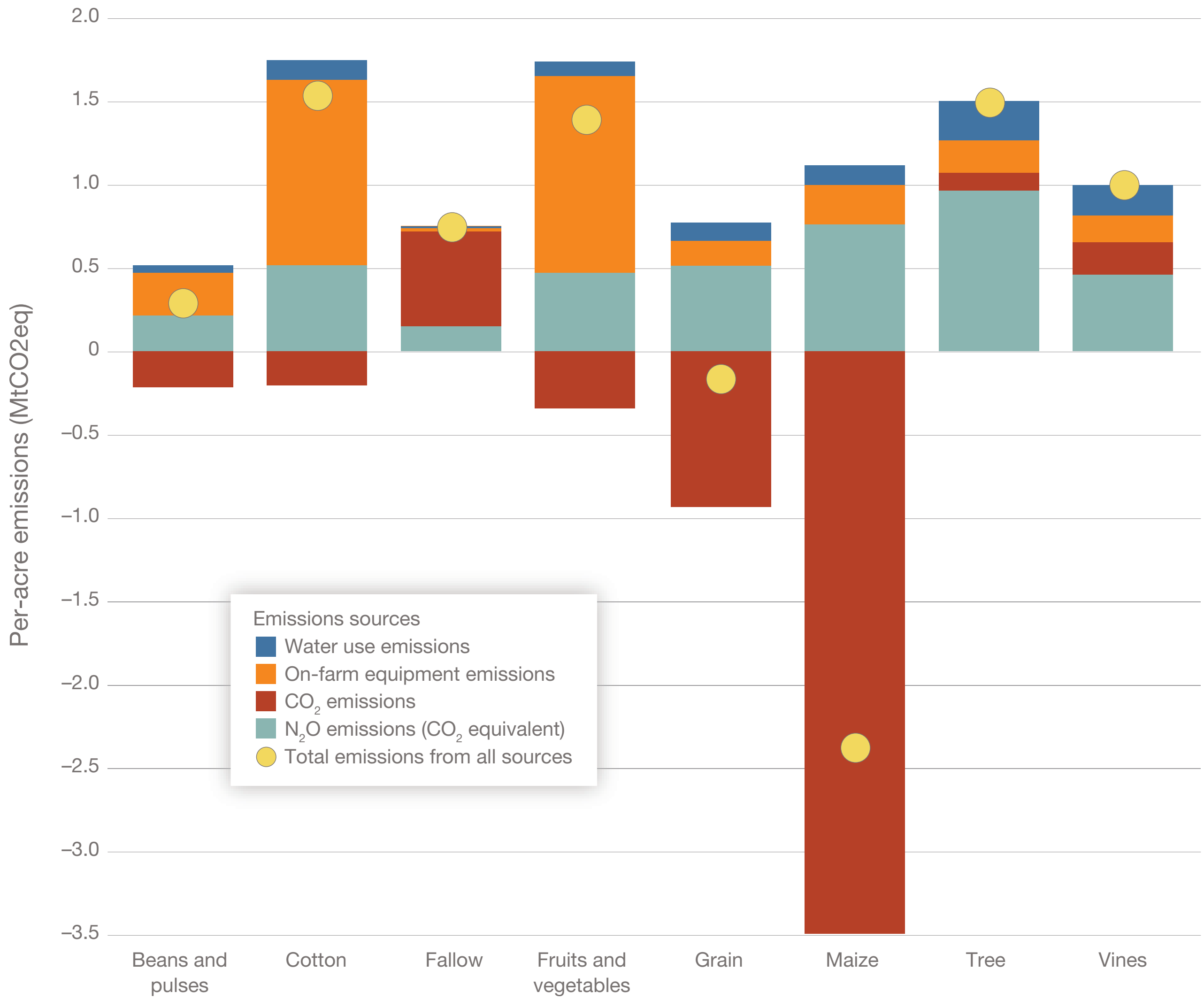
carbon than they release, and more-widespread planting of such crops could offset emissions further. Such a strategy would need to consider the value of such crops and any changes in overall irrigation demand for the district.

California Agencies Can Encourage Adoption of High-Impact, Emissions-Reducing Actions

This study has several implications for state and local policymakers and agencies and others that seek to reduce GHG emissions with supporting policies and programs. First, this study shows that it is not straightforward whether a particular agricultural region is a carbon source or sink, and determining this requires

FIGURE 2

Average Annual Emissions per Acre by Crop Group



careful analysis of its agricultural practices, including crop types, soil management practices, and energy sources for irrigation. It further shows that, even for regions that have implemented programs for renewable energy and energy and water efficiency, crop production could remain a positive source of GHG emissions. Therefore, decisions at the regional level will require region-specific analyses such as this to guide their emissions reduction activities.

Second, this study identified several agricultural practices that are particularly important for reducing GHGs and provides evidence in support of state programs that currently support these practices. This includes using renewables to power groundwater pumping, a practice supported by the California Department of Food and Agriculture (CDFA) State Water Efficiency and Enhancement Program to target crop emissions.[7] It also includes using low-till or no-till practices and crop rotations, which are supported by CDFA's Healthy Soils Program.[8] No-till practices can significantly reduce emissions by retaining more carbon in soils and reducing the amount of on-farm equipment needed for full tillage. This practice, according to the modeling, does not require additional water for irrigation and might even introduce potential water savings through improved water retention in soils.

Third, the findings suggest other practices that could be supported alongside or within these existing programs, such as planting specific crops or crop mixes that sequester carbon. In addition, while not covered in detail in this work, on-farm electrification investments could reduce average annual emissions by around 10 to 30 percent if all vehicles and equipment are converted. The impact will vary significantly by crop type and local practices. The California Air Resource Board supports funding for zero-emissions and lower-emission on-farm equipment.[9] In conversations with growers in Westlands, the authors found that although interest in on-farm electrification does exist, a lack of availability of this type of equipment (e.g., electric tractors) in the market limits the ability of growers to electrify their equipment. This is an area in which further state and federal policy could support investments in research and development.

Fourth, although farming does emit GHGs, converting agricultural land to solar photovoltaics is one option for substantially offsetting agricultural emissions. Solar could also help reduce the demand for water in agriculture. During California's 2012 to 2016 drought, about half a million acres or 6 percent of the state's irrigated crop area was fallowed or idled, which included the removal of mature orchards.[10] This led to lasting changes in water use and agricultural output. Given projected long-term aridification and increases in the duration and frequency of similar droughts, some land conversion to solar could offer both water resources and decarbonization benefits for the state. However, any policy that supports land conversion to solar comes at a potential trade-off of loss of cultivated acreage. Therefore, such a policy could be aimed at permanently fallowed, irrigation-impaired lands or other lands where water availability might be limited.

Additional Research Can Further Support Decarbonization Goals

This work points the way to several analytical next steps to inform policy. First, this kind of analysis could be repeated for other California crop-producing regions, which will grow different crops, use different agriculture practices, and experience different climatic conditions, now and in the future.

Second, the scope of analysis can be expanded in several ways to include (1) the broader agricultural supply chain, including life-cycle emissions of agricultural inputs and the processing and packaging of agricultural outputs, (2) the costs and co-benefits of various mitigating actions, and (3) decision support tools to illustrate the key trade-offs discussed in this work, such as GHG emissions, water use, labor hours, and costs, which could support growers, agricultural districts or state decisionmakers in selecting and implementing lower-emissions agricultural options.

Finally, this analysis can be strengthened with field work to validate modeling results or suggest changes to modeling parameters and methods. Further research is also needed to identify practices that specifically reduce emissions from higher-value tree crops that are commonly grown across California's Central Valley, such as almonds and pistachios.

Notes

[1] California State Assembly, Assembly Bill 1757, Chapter 341, An Act to Add Section 38561.5 to the Health and Safety Code, Relating to Greenhouse Gases, September 16, 2022. As of February 8, 2023:
https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220AB1757

[2] These findings are subject to simplifying assumptions. The authors accounted for future climate change and future changes in the carbon intensity of California's electricity grid. Other future sources of change were not included.

[3] This assumes that current California policies on decarbonization are realized.

[4] Crop groups were created by grouping Westlands' wide range of crop types into higher-level categories.

[5] Such a strategy could present trade-offs related to crop production, but this was beyond the scope of this study.

[6] Except for those lands acquired by Westlands and permanently retired under the settlement in Sumner Peck Ranch, et al., v. Bureau of Reclamation, et al., CV-F-91-048 OWW (U.S. District Court Eastern District of California).

[7] California Department of Food and Agriculture, "Office of Environmental Farming & Innovation," webpage, undated. As of August 3, 2022:
https://www.cdfa.ca.gov/oefi/

[8] California Department of Food and Agriculture, "Healthy Soils Program," webpage, undated. As of August 3, 2022:
https://www.cdfa.ca.gov/oefi/healthysoils/

[9] California Climate Investments, "Funding Agricultural Replacement Measures for Emission Reductions," webpage, undated. As of August 3, 2022:
https://www.caclimateinvestments.ca.gov/farmer

[10] Jay Lund, Josue Medellin-Azuara, John Durand, and Kathleen Stone, "Lessons from California's 2012–2016 Drought," *Journal of Water Resources Planning and Management*, Vol. 144, No. 10, 2018.

This brief describes work done in RAND Social and Economic Well-Being and documented in *Growing Toward a Low-Carbon Future: Estimating Greenhouse Gas Emissions in California's Westlands Water District*, by Michelle E. Miro, Nidhi Kalra, Jonathan Lamb, and Nihar Chhatiawala, RR-A2246-1, 2023 (available at www.rand.org/t/RRA2246-1). To view this brief online, visit www.rand.org/t/RBA2246-1. The RAND Corporation is a research organization that develops solutions to public policy challenges to help make communities throughout the world safer and more secure, healthier and more prosperous. RAND is nonprofit, nonpartisan, and committed to the public interest. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors. **RAND**® is a registered trademark.